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CASE REPORT

REACTIVE NEUROMUSCULAR TRAINING RESULTS IN IMMEDIATE AND LONG TERM IMPROVEMENTS IN MEASURES OF HAMSTRING FLEXIBILITY: A CASE REPORT

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ABSTRACT

Background and Purpose: Hamstring tightness is a common complaint among active individuals and patients are traditionally classified with tight hamstrings based on commonly accepted clinical exams including the active knee extension, active straight leg raise, and passive straight leg raise tests. Apparent hamstring tightness is a condition that is present in patients who have the perception of hamstring tightness and are classified with a tissue extensibility dysfunction but demonstrate immediate gains in hamstring range of motion following an intervention that does not address a tissue length dysfunction. Reactive neuromuscular training can be used as part of the evaluative process used to classify and treat patients with apparent hamstring tightness. The purpose of this case report was to identify, treat, and report the outcomes experienced when using a reactive neuromuscular training technique on a patient who was classified with hamstring inflexibility based on traditional testing methods.

Case Description: A 20 year-old female softball player presented with a chief complaint of hamstring tightness of more than four years duration. The patient tested positive for hamstring inflexibility based on traditional testing methods. The patient was then treated using a reactive neuromuscular training technique in which the patient resisted a manual anterior to posterior force at the abdomen, sternum and across the hips while simultaneously bending forward at the hips in an attempt to touch her toes.

Outcomes: Following one reactive neuromuscular training treatment session the patient tested negative for hamstring inflexibility based on traditional testing methods and maintained those results at a five-week follow-up appointment.

Discussion: The subject in this case report demonstrated the effectiveness of reactive neuromuscular training in identifying and treating apparent hamstring tightness. Based on these findings, clinicians should consider using reactive neuromuscular training to properly classify and treat patients with a chief complaint of hamstring "tightness."

Level of Evidence: 4 (single case report)

Keywords: Apparent hamstring tightness, patient classification, treatment based classification

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BACKGROUND AND PURPOSE

Hamstring tightness is a common complaint among active individuals.[1] In the clinical setting, patients who present with limited range of motion (ROM) on the active knee extension (AKE), passive straight leg raise (PSLR), and active straight leg raise (ASLR) tests are commonly classified with tight hamstrings and treated with traditional stretching techniques.[2–5] Stretching activities are commonly used in health-care to improve joint ROM,[6–10] and the American College of Sports Medicine recommends routine flexibility exercises to maintain and improve joint ROM.[11] The current literature on the most effective methods to improve ROM via stretching is inconsistent,[7] and recent evidence suggests increases in ROM following a stretching program may not be due to increases in tissue length, but rather, are caused by an increase in stretch tolerance.[12–14] In addition, there is evidence to suggest that some types of stretching may negatively impact muscle strength and power under specified stretching parameters.[15–17] Given the proposed effects of stretching and the current method of classifying hamstring tightness, clinicians must ensure the cause of the apparent "tightness" warrants the application of stretching interventions prior to recommending any stretching program.

Apparent hamstring tightness is a provisional classification for those patients who have been identified as having hamstring tightness using traditional measures (e.g., AKE, PSLR). The importance of a provisional classification of apparent hamstring tightness is that testing may lead to a more definitive classification of tissue extensibility dysfunction (TED), which is a dysfunction in the length or extensibility of multi-articular soft tissue structures (i.e., muscle, fascia, nervous tissue) identified through the Selective Functional Movement Assessment (SFMA).[4] However, recent clinical practice findings demonstrate that these apparent hamstring tightness or TEDs (based on special test findings) can often be resolved in a single treatment session that does not directly involve lengthening structures. If one follows the current accepted classification pathway based on exam findings (i.e., hamstring tightness or TED), then this classification would lead the clinician to a local treatment (e.g., stretching, instrument assisted soft tissue mobilization) which may or may not resolve the "tightness." The problem with assuming local tightness or TED, is that the clinician may wrongly lengthen a normal tissue (e.g. hamstrings), when the results (e.g., negative special tests) may be gained by using non-local, non-structural lengthening techniques. An alternate hypothesis is that the apparent tightness may be a low level contraction of some fibers of a muscle (e.g., non-local stability motor control dysfunction, trigger point), which presents with similar symptoms of a TED during a traditional clinical exam. In many cases, non-traditional treatment options, such as a stability motor control intervention (e.g., reactive neuromuscular training) at a proximal or distal segment, a regional interdependence approach (e.g., Total Motion Release[18]), or slacking the local tissue instead of stretching it (e.g., positional release therapy[19]), will immediately resolve the apparent tissue tightness.

One proposed method to differentially diagnose a true TED from apparent hamstring tightness is to use a treatment based classification (TBC) system to classify patients prior to treatment. One potential component of a TBC system for hamstring tightness is reactive neuromuscular training (RNT). The term RNT was first introduced by Voight and Cook[20] and is utilized to restore functional stability about the joint and enhance motor control skills. Individualized RNT techniques are thought to correct motor pattern dysfunctions by applying a light external load to exaggerate the dysfunctional movement and cause the patient to reactively correct the subconscious dysfunctional movement pattern.[4] Current literature on the use of RNT is lacking, but the results of one case report suggested that a rehabilitation program utilizing RNT that consisted of exercises that focused on promoting proper body positioning and posture by having the patient react to an outside force (e.g., elastic tubing) that promoted an unwanted movement pattern quickly improved apparent strength deficits in a patient with an anterior cruciate ligament deficient knee.[21]

It is hypothesized that patients who present with hamstring tightness may be experiencing a dysfunctional motor control pattern in which the normal firing pattern of the postural (i.e., static) muscles is delayed or sub-optimal causing the hamstring muscle group to function as a stabilizer versus their normal function as a prime mover. Therefore, this alteration of the hamstring muscle group's function results in the presentation of apparent hamstring tightness. The proposed use of a specific RNT technique may help classify and correct this dysfunctional motor control pattern by reflexively inhibiting the hamstring muscle group and activating the postural stabilizers. While variations exist, the recommended application begins with the clinician applying a manual anterior-posterior (AP) force to the center of a patient's abdomen (i.e., umbilicus), sternum, and/or across the hips bilaterally at the level of the anterior superior iliac spine while instructing the patient to prevent the clinician from pushing him/her backwards. Once the patient "stops" the AP force provided by the clinician, the patient reacts simultaneously by bending forward at the hips in an attempt to "touch" his/her toes (Multi-segmental forward flexion) (Figure 1). The patient should complete five to ten reactive forward flexion bends with the clinician applying the AP force prior to each repetition. Multiple sets of this maneuver can be performed in a single treatment session and the clinician may adjust the location (superior or inferior) of the AP force throughout the treatment session. The clinician can choose to adjust the location of the AP force in an attempt to find the location that produces the greatest increase in forward flexion by producing the optimal motor control pattern for performing forward flexion.

Patients who do not have a true hamstring TED, and have a possible motor control pattern dysfunction, will quickly improve their multi-segmental forward flexion ROM during the initial RNT treatment session. As a result of this change, the patient can be classified as having apparent hamstring tightness and would not be indicated to receive a treatment protocol designed at increasing tissue extensibility (e.g., stretching). The purpose of this case report was to identify, treat, and report on the patient outcomes while using this RNT technique on a patient who demonstrated hamstring inflexibility based on the traditional testing methods.

CASE DESCRIPTION

A 20-year-old, female softball player agreed to participate after she was informed of the purpose of this case study. The patient denied any recent history of lower extremity, lumbar, or thoracic injury. She did report chronic hamstring tightness of more than four years duration despite the use of traditional warm-up and stretching techniques. The patient reported no additional health history that would have affected trunk or lower extremity ROM and was otherwise healthy.

Figure 1. *Reactive Neuromuscular Training (RNT) technique used to identify and treat apparent hamstring tightness. (A) Clinician applies an anterior-posterior force and (B) the patient simultaneously reacts by reaching for his/her toes.*

INITIAL CLINICAL IMPRESSION

The cause of the patient's chief complaint of chronic hamstring tightness was hypothesized to be a result of apparent hamstring tightness since the patient reported no improvement following traditional warm-up and stretching interventions. Further ROM testing was performed in order to identify whether the patient could be classified with hamstring tightness based on traditional evaluation techniques.

EXAMINATION

Prior to beginning the clinical examination the patient performed a warm up which consisted of five consecutive standing toe touches in order to reduce the potential mobilizing effect from performing repetitive hip flexion measurements.[22] Immediately after the warm up, the following ROM measurements were taken: (a) ASLR, (b) PSLR, (c) AKE, (d) finger to floor distance test (FFD), (e) sit and reach (SnR), (f) modified Shober (mShober), (g) seated sacral angle (SA), and (h) standing SA. Range of motion measurements for the ASLR, PSLR, AKE, and SA were taken using an iPhone 5s with the Clinometer (Plaincode, http://www.plaincode.com/products/clinometer/) application which has previously been shown to be reliable at measuring ROM in the shoulder[23] and cervical spine.[24] The FFD, SnR and mSchober were measured using a cloth measuring tape.

Normal ROM on the ASLR and PSLR tests has been suggested as 70° or more and 80° or more of hip flexion respectively.[4] For the AKE test, a knee flexion angle of 20° or less has been used to define normal ROM.[3] During the clinical examination, the patient's ROM measurements (Table 1) on the ASLR (R = 60°, L = 58°), PSLR (R = 67°, L = 70°), and AKE (R = 30°, L = 34°) tests all fell outside of the normal ROM limits.

CLINICAL IMPRESSION AFTER EXAMINATION

Based on the ROM measurements during the clinical examination, the patient was classified as having a potential TED. The clinical examination results were consistent with the patient's chief complaint of hamstring tightness, but had remained despite regular stretching techniques applied as part of her pre-sport warm-up. As such, the use of RNT as a screening and intervention technique to identify if the patient has apparent hamstring tightness was warranted.

Table 1. *Clinical evaluation range of motion measurements pre-and post- reactive neuromuscular treatment including 5 week follow-up testing and total change in range of motion*

	Pre-Treatment	Post-Treatment	5 Week Follow-up	Total Change
ASLR Right	60º	75º	85º	25º
ASLR Left	58º	80º	90º	32º
PSLR Right	67º	83º	92º	25º
PSLR Left	70º	84º	93º	23º
AKE Right	30º	11º	0º	30º
AKE Left	34º	18º	0º	34º
SA (Standing)	60º	71º	60º	0º
SA (Seated)	75º	85º	74º	-1º
mSchober	21.25cm	21cm	22cm	0.75 cm
FFD	1cm	-3.5cm	-3.5cm	4.5cm
S&R	0cm	-4.0cm	-3.5cm	3.5cm

ASLR= Active Straight Leg Raise
PSLR= Passive Straight Leg Raise
AKE= Active Knee Extension
SA= Sacral Angle
mSchober= Modified Schober
FFD= Finger to Floor Distance
S&R= Sit and Reach

INTERVENTION

The patient was treated with an RNT technique immediately following ROM measurements. Treatment began by having the patient stand with her feet together while the clinician provided a mild AP force to the patient's abdomen. The patient resisted this force and simultaneously completed the multi-segmental forward flexion pattern while the clinician maintained application of the force. Upon completion of the repetition, the clinician re-applied the force and the process was repeated for a set of 10 repetitions with the force being re-applied prior to each repetition. The clinician then provided the AP force on the superior portion of the sternum for approximately five repetitions and an additional five to eight repetitions were performed with the clinician providing the AP force at the level of the anterior superior iliac spines. The clinician paused treatment between each set to inform the patient of the change in location of the AP force but no additional rest was given. Total treatment time was less than three minutes. Immediately following the RNT treatment, ROM measurements were repeated. After the initial treatment was complete, the patient was instructed to resume normal daily and sport activities. The patient returned to the athletic training clinic five weeks after initial treatment for follow-up testing. The patient reported she did not participate in any additional RNT treatments or additional stretching activities outside of her normal sport activities between the initial treatment session and follow-up testing.

OUTCOMES

All post-treatment and follow-up ROM measurements are included in Table 1. The patient had an increase in post-treatment ROM on the ASLR (R = 15°, L = 22°), PSLR (R = 16°, L = 14°), and AKE (R = 19°, L = 16°) from the initial treatment. At the five week follow up, the patient further increased ROM compared to initial measurements on the ASLR (R = 25°, L = 32°), PSLR (R = 25°, L = 23°), and AKE (R = 30°, L = 34°). In addition, FFD post-treatment improved 4.5 cm from the single treatment and the patient maintained that improvement at the five week follow up. Sit and reach measurements were similar to the FFD measurements with a 4 cm improvement post-treatment and a 3.5 cm improvement at the five week follow up. The patient did not demonstrate any change in the mSchober following treatment; however, her SA measurements improved (10° sitting, 11° standing) at the initial post-measurements, but were not maintained at the five week follow up.

DISCUSSION

Prior to RNT treatment, ROM measurements on the ASLR, PSLR, and AKE tests would classify the patient as having had tight hamstrings resulting from a TED.[2,10,21] Following one treatment session with a RNT exercise intervention, the movement improved and her hamstrings were within normal ROM limits[21] on each of the above tests. At the five week follow up appointment, the patient's ROM measurements on the ASLR, PSLR, and AKE remained within the normal limits and had increased from the initial post-treatment measurements. The patient denied making any changes to her physical activity level or training program following initial treatment and did not receive any additional treatments aimed at increasing hamstring flexibility.

While only one patient, these findings indicate superior results compared to stretching studies that have assessed similar outcome measures. De Weijer, Gorniak, and Shamus[25] found patients achieved an immediate increase in ROM on the AKE test of about 13° following a single session of three sets of 30 second passive static stretches; however, after 24 hours the post-stretch increase in ROM decreased to just under 8° and no additional follow-up testing was performed. Bandy, Irion, and Briggler[10] reported similar results following a six-week stretching program. In their study, patients in the stretching groups gained, on average, between 10.5° and 11.5° of knee extension on the AKE test. Similarly, Cipriani, et al[26] reported an 18.1° increase in ROM on the PSLR test following a four-week static stretching program, but also reported a steady decrease in ROM in the same patients during the subsequent four weeks after discontinuing the stretching program. The patient in this case study demonstrated a greater increase in ROM on the AKE test immediately following a single treatment session of RNT (R = 19°, L = 16°) without utilizing any treatment designed to directly elongate tissue. More importantly, the patient demonstrated further increases in ROM at a five-week follow up (R = 30, L = 34) without any additional RNT treatment sessions, as opposed to the decrease in ROM that was seen in the stretching studies.[25,26]

The gains in ROM seen in this patient immediately following RNT treatment and the increased gains in ROM at a five-week follow up meet or exceed the increases in ROM identified in traditional stretching literature.[8,10,25,26] The results may be explained by a change in motor pattern function as a result of the RNT intervention and suggests it is unlikely the patient had a hamstring length deficit prior to treatment despite the positive tests for hamstring tightness. More importantly, the results of this case report identify a potential flaw in the current thinking regarding evaluation and treatment of hamstring tightness. Current evaluation techniques may be unable to differentiate between true and apparent hamstring tightness; therefore, patients may often be incorrectly prescribed stretching interventions which may be contraindicated if the clinician is lengthening tissue that does not require tissue elongation. Clinicians should consider using treatment based assessment techniques to differentiate between true and apparent hamstring tightness. Future research needs to be conducted on a larger population in order to determine the reliability and validity of using the proposed RNT treatment as an individual treatment for apparent hamstring tightness, as well as using it as part of a more comprehensive hamstring tightness TBC system. In addition, further research needs to identify if a true change in motor control occurs with RNT, and if that change correlates with improved athletic performance and/or injury prevention.

CONCLUSION

The results of this case report demonstrate that the subject did not have a TED despite fitting that classification based on the use of traditional evaluation techniques to assess hamstring flexibility. The use of an RNT intervention allowed for quick identification of the apparent hamstring tightness and improved all of the patient's ROM measurements in only three minutes of treatment. The improvements were maintained at a five-week follow-up appointment without any further treatment being applied. Based on these results, clinicians should consider utilizing the described RNT intervention as a screening tool within the differential diagnostic process, and as a treatment for patients who present with signs of hamstring tightness. The use of such interventions may lead to the development of an efficient and effective treatment based classification system for improving outcomes in patients who present with hamstring flexibility issues.

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